PATENT COOPERATION TREATY

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INTERNATIONAL SEARCHING AUTHORITY

To:

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PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY
(PCT Rule 43*bis*.1)

Date of mailing (*day/month/year*) see form PCT/ISA/210 (second sheet)		
Applicant's or agent's file reference see form PCT/ISA/220	**FOR FURTHER ACTION** See paragraph 2 below	
International application No. PCT/US2005/003156	International filing date (*day/month/year*) 31.01.2005	Priority date (*day/month/year*) 05.02.2004
International Patent Classification (IPC) or both national classification and IPC H04L25/02		
Applicant QUALCOMM INCORPORATED		

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☒ Box No. II Priority
- ☒ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☒ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA"). However, this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notifed the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of three months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Baltersee, J Telephone No. +49 89 2399-7126

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2005/003156

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This opinion has been established on the basis of a translation from the original language into the following language , which is the language of a translation furnished for the purposes of international search (under Rules 12.3 and 23.1(b)).

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

      ☐ a sequence listing

      ☐ table(s) related to the sequence listing

   b. format of material:

      ☐ in written format

      ☐ in computer readable form

   c. time of filing/furnishing:

      ☐ contained in the international application as filed.

      ☐ filed together with the international application in computer readable form.

      ☐ furnished subsequently to this Authority for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

Box No. II Priority

1. ☒ The validity of the priority claim has not been considered because the International Searching Authority does not have in its possession a copy of the earlier application whose priority has been claimed or, where required, a translation of that earlier application. This opinion has nevertheless been established on the assumption that the relevant date (Rules 43*bis*.1 and 64.1) is the claimed priority date.

2. ☐ This opinion has been established as if no priority had been claimed due to the fact that the priority claim has been found invalid (Rules 43*bis*.1 and 64.1). Thus for the purposes of this opinion, the international filing date indicated above is considered to be the relevant date.

3. Additional observations, if necessary:

Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application,

☒ claims Nos. 10

because:

☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination *(specify)*:

☒ the description, claims or drawings *(indicate particular elements below)* or said claims Nos. 10 are so unclear that no meaningful opinion could be formed *(specify)*:

see separate sheet

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the whole application or for said claims Nos.

☐ the nucleotide and/or amino acid sequence listing does not comply with the standard provided for in Annex C of the Administrative Instructions in that:

the written form	☐	has not been furnished
	☐	does not comply with the standard
the computer readable form	☐	has not been furnished
	☐	does not comply with the standard

☐ the tables related to the nucleotide and/or amino acid sequence listing, if in computer readable form only, do not comply with the technical requirements provided for in Annex C-*bis* of the Administrative Instructions.

☐ See separate sheet for further details

Box No. IV Lack of unity of invention

1. ☒ In response to the invitation (Form PCT/ISA/206) to pay additional fees, the applicant has:

   ☒ paid additional fees.

   ☐ paid additional fees under protest.

   ☐ not paid additional fees.

2. ☐ This Authority found that the requirement of unity of invention is not complied with and chose not to invite the applicant to pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rule 13.1, 13.2 and 13.3 is

   ☐ complied with

   ☒ not complied with for the following reasons:

   see separate sheet

4. Consequently, this report has been established in respect of the following parts of the international application:

   ☒ all parts.

   ☐ the parts relating to claims Nos.

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	6, 8, 12, 21, 22, 25, 33, 34
	No:	Claims	1-5, 7, 9, 11, 13-20, 23, 24, 26-32
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-9, 11-34
Industrial applicability (IA)	Yes:	Claims	1-9, 11-34
	No:	Claims	

2. Citations and explanations

   see separate sheet

Re Item III

Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

Invention IV.

1. According to claim 10, the third channel estimate is obtained by frequency interpolation of the channel gain estimates for the first and second groups of subbands. According to antecedent claim 9, however, the third channel estimate is obtained by concatenation of the channel gain estimates for the first and second groups of subbands. In other words, the result of the concatenation according to claim 9 (and according to the description, paragraph 48), is a channel estimate for all defined subbands, namely the first and second group of subbands. Applying an interpolation to that result does not seem to make any sense, since interpolation means that channel gain estimates at some intermediate subbands are derived. The third channel estimate according to claim 9, however, already comprises channel gain estimates for all defined subbands. It appears that only a smoothing of the third channel estimate would make sense. Smoothing, however, is not disclosed in the present application. Paragraph 48 discloses, in that respect, equation (16) according to which a revised initial frequency response is multiplied by an NxP submatrix of an NxN DFT matrix. However, since the revised initial frequency response is obtained for all N subbands by concatenation, it must be represented by an Nx1 vector. It is thus impossible to multiply the vector representing the revised initial frequency response by an NxP matrix. If the skilled person assumed an error and interpreted the equation as multiplying said Nx1 by an NxN DFT matrix, the result would be another Nx1 vector representing an impulse response. Then, however, the (non-optional) zero-padding operation described in the text passage following equation (16) also does not appear to make any sense.

   It thus appears that claim 10 is not adequately supported by the description, as required by Article 6 PCT. Furthermore, it appears that the underlying embodiment, as disclosed in paragraph 48 of the description, does not contain sufficient information to enable the skilled person to carry out said embodiment.

It is therefore concluded that claim 10 and the corresponding parts of the description are so unclear, that no meaningful opinion can be formed on the novelty, inventive step, or industrial applicability of claim 10 (Article 34(4)(a)(ii) PCT).

Re Item IV

Lack of unity of invention

1. This International Preliminary Examining Authority found multiple (groups of) inventions in this international application, as follows:

   1. Claims 1-4, 12, 15-19, 26-28, 30, 31:
   Joint detection and estimation of two superposed data streams

   2. Claims 5-7:
   Enabling further processing or refinement of a frequency domain channel estimate in the time-domain

   3. Claim 8:
   Enabling further processing or refinement of a time-domain channel estimate in the frequency domain

   4. Claims 9-11:
   Iterative channel estimation in a multicarrier communication system

   5. Claims 13-14, 29, 32-34:
   Iterative channel estimation based on remodulated symbols

   6. Claims 20-22:
   Refinement of frequency-domain channel estimates

   7. Claims 23-25:
   Pilot-based channel estimation in an multicarrier communication system

   The application lacks unity within the meaning of Rule 13 PCT. In the light of the relevant

prior art document D1, an objection of *a posteriori lack of unity* arises (see PCT Guidelines, Gazette, Section IV, III 7.5). The reasons therefor are the following:

2. The following prior art document was found during the search and proved to be relevant for assessment of unity of the above cited inventions.

D1: KALEONG LO ET AL: "Layered space time coding with joint iterative detection, channel estimation and decoding" SPREAD SPECTRUM TECHNIQUES AND APPLICATIONS, 2002 IEEE SEVENTH INTERNATIONAL SYMPOSIUM ON SEPT. 2-5, 2002, PISCATAWAY, NJ, USA,IEEE, vol. 2, 2 September 2002 (2002-09-02), pages 308-312, XP010615481 ISBN: 0-7803-7627-7

The document D1 discloses (the references in parentheses applying to this document) according to all features of claim 1,

A method of recovering first and second data streams transmitted simultaneously via a wireless channel in a wireless communication system (see page 308, right-hand column, up to and including Figure 1 which discloses nT data streams transmitted simultaneously over a wireless channel in a wireless communication system, and page 308, right-hand column, text following Figure 1 - page 309, left-hand column, up to Section III, which discloses recovering the nT transmitted data streams), comprising:

deriving a first channel estimate for the wireless channel based on received symbols (see page 311, left-hand column, up to the first two lines after equation (18));
performing detection for the first data stream using the first channel estimate (see Figure 3 and page 311, left-hand column, up to the first two lines after equation (18), at the first iteration, the first, pilot-based, channel estimate is used in the parallel interference cancellation detector which detects the nT data streams);
deriving a second channel estimate based on the detected first data stream (see page 311, left-hand column, equation (19), which shows how to calculate a second channel estimate at iteration k=2, based on the first channel estimate at iteration k=1);
deriving a third channel estimate based on the first and second channel estimates (see, for example, page 311, left-hand column, equation (19), which shows how to calculate a third channel estimate at iteration k=3, based on the second channel estimate at

iteration k=2 which in turn is based on the first channel estimate at iteration k=1, or, alternatively, page 311, left-hand column, equation (21), which shows how to calculate a third channel estimate at iteration k=2, based on the second estimate at iteration k=2 and the first estimate at iteration k=1); and
performing detection for the second data stream using the third channel estimate (see Figure 3 and page 311, left-hand column, equation (19), at the third iteration, the third channel estimate is used in the parallel interference cancellation detector which detects the nT data streams).

Independent claims 27 and 30 contain essentially the same technical features as claim 1, except that they are formulated as apparatus features. Therefore, document D1 discloses all the features of claims 27 and 30 as well.

The technical features of dependent claim 3 are also known from document D1, i.e.

estimating interference due to the first data stream using the third channel estimate (see page 311, left-hand column, equation (3): in iteration k=4 the interference due to the first data stream is estimated using the channel estimate from iteration k=3), and wherein the detection for the second data stream is performed with the estimated interference from the first data stream cancelled (see Figure 3 and page 311, left-hand column, equation (3): the channel estimate from transmit antenna l to receive antenna j is computed with the interference due to the other transmit antennas cancelled. Since transmit antenna l is associated with data stream l, the channel estimate from transmit antenna l to receive antenna j is computed with the interference due to the other data streams cancelled. The channel estimate from transmit antenna 2 to any receive antenna is thus computed with the interference from the first data stream cancelled. Consequently, all the data streams, and thus the second data stream, are detected with the estimated interference from the first data stream cancelled from this channel estimate).

It follows from a comparison of the present set of claims with document D1 that the following technical features could potentially make a contribution over this prior art, and as such may be regarded as special technical features in the sense of Rule 13.2 PCT:

- Invention **1.** (Claim 4): first and second data streams are combined prior to

transmission via the wireless channel

- Invention **2.** (Claim 5): obtaining a frequency response estimate for the wireless channel based on the received pilot symbols, deriving a time-domain impulse response estimate for the wireless channel based on the frequency response estimate, and deriving the first channel estimate based on the time-domain impulse response estimate

- Invention **3.** (Claim 8): the third channel estimate is a frequency response estimate derived by combining and transforming the time-domain impulse response estimates for the first and second channel estimates

- Invention **4.** (Claim 9): the first channel estimate comprises channel gain estimates for a first group of subbands and the second channel estimate comprises channel gain estimates for a second group of subbands, and wherein the third channel estimate is derived based on a concatenation of the channel gain estimates for the first and second groups of subbands

- Invention **5.** (Claim 13): re-encoding the decoded data to obtain remodulated symbols for the first data stream, and wherein the second channel estimate is derived based on the remodulated symbols and the received data symbols.

- Invention **6.** (Claim 20): filtering the first, second or third channel estimate in frequency domain.

- Invention **7.** (Claim 24): the received pilot symbols are obtained in each OFDM symbol period and for a set of subbands used for pilot transmission.

A comparison reveals that there is no technical relationship among these inventions involving one or more of the same special technical features (Rule 13.2 PCT).

The objective technical problems which are solved by the special technical features of inventions **1.** to **6.** may be regarded as follows:

- Invention **1.**: In the prior art document D1, the different data streams are not combined prior to transmission, but each stream is transmitted separately via a different transmit antenna. The effect of combining the data streams prior to transmission, as claimed by claim 4, is that the different data streams interfere with each other in another way than in the disclosed prior art, and thus the method for recovering the two data streams according to the prior art has to be adapted accordingly. The problem solved by claim 4 may thus be regarded as how to jointly detect data and estimate a channel of two superposed data streams?

- Invention **2.**: Prior art document D1 assumes MIMO wireless transmission over a flat fading channel (see page 308, lines 1-3 of Section 2.). It is well known in the art, that realistic wireless channels are not of a flat, but a frequency selective nature, and that OFDM is the method of choice to covert a frequency-selective MIMO channel into a frequency-flat MIMO channel (see, for example, PAULRAJ A ET AL: "Introduction to Space-Time Wireless Communications" May 2003 (2003-05), CAMBRIDGE UNIVERSITY PRESS , CAMBRIDGE, U.K. , XP002333354 ISBN: 0 521 82615 2, pages 178-184). In such an OFDM system, a frequency response estimate is usually used for performing detection. The additional contribution of claim 5 may thus be regarded as a further postprocessing of the frequency domain channel estimate, presumably for enabling a refinement of the channel estimate in the time-domain. The problem solved by claim 5 may thus be regarded as how to enable further processing or refinement of a frequency domain channel estimate in the time-domain?

- Invention **3.**: Document D1 discloses on page 311, left-hand column, equation (21), deriving a third channel estimate by combining the time-domain impulse response estimates for the first and second channel estimates. The effect of the additional feature of claim 8 (transforming the combined time-domain impulse response estimates) is thus the transformation of the third channel estimate into the frequency domain. The problem solved by claim 8 may thus be regarded as how to enable further processing or refinement of a time-domain channel estimate in the frequency domain?

- Invention **4.**: Document D1 does not disclose features related to claim 9. The effect

of these distinguishing features is to obtain channel estimates for a set of subbands, wherein the channel estimate for the second group of subbands is derived based the detected first data stream The problem solved by claim 9 may thus be regarded as how to iteratively obtain a channel estimate in a multicarrier communication system ?

- Invention **5.**: Document D1 discloses in Figure 1 and on page 311, left-hand column, paragraph starting after equation (18) up to equation (20) deriving the second channel estimate based on the soft-symbol estimates of the first data stream and the received data symbols. Unlike claim 13, the soft-symbol estimates are not channel decoded and re-encoded to obtain remodulated symbols. The problem to be solved by claim 13 may thus be regarded as how to carry out iterative channel estimation based on remodulated symbols?

- Invention **6.**: Prior art document D1 assumes MIMO wireless transmission over a flat fading channel (see page 308, lines 1-3 of Section 2.). It is well known in the art, that realistic wireless channels are not of a flat, but a frequency selective nature, and that OFDM is the method of choice to covert a frequency-selective MIMO channel into a frequency-flat MIMO channel (see, for example, PAULRAJ A ET AL: "Introduction to Space-Time Wireless Communications" May 2003 (2003-05), CAMBRIDGE UNIVERSITY PRESS , CAMBRIDGE, U.K. , XP002333354 ISBN: 0 521 82615 2, pages 178-184). In such an OFDM system, a frequency response estimate is usually used for performing detection. The additional contribution of claim 5 may thus be regarded as how to refine frequency-domain channel estimates?

- Invention **7.**: Prior art document D1 assumes MIMO wireless transmission over a flat fading channel (see page 308, lines 1-3 of Section 2.). It is well known in the art, that realistic wireless channels are not of a flat, but a frequency selective nature, and that OFDM is the method of choice to covert a frequency-selective MIMO channel into a frequency-flat MIMO channel (see, for example, PAULRAJ A ET AL: "Introduction to Space-Time Wireless Communications" May 2003 (2003-05), CAMBRIDGE UNIVERSITY PRESS , CAMBRIDGE, U.K. , XP002333354 ISBN: 0 521 82615 2, pages 178-184). In such an OFDM system, a frequency

response estimate is usually used for performing detection. The additional contribution of claim 5 may thus be regarded as how to carry out pilot-based channel estimation in a multicarrier system?

The problems underlying inventions **1.** to **7.** are completely unrelated to each other, and thus none of the potential special technical features of the respective inventions may be regarded to function in an equivalent, or complementary, or cooperative manner, nor are they specially adapted to each other. Therefore, no corresponding special technical features in the sense of Rule 13.2 PCT can be ascribed to the inventions **1.** to **7.**

3. The (group of) inventions **1.** to **7.** are thus neither linked by a single general inventive concept, nor do they fulfil the requirement of Rule 13.2 PCT that an international patent application may include a group of inventions if there is a technical relationship among those inventions involving **one or more of the same, or corresponding** *special technical features* which make as a whole a inventive contribution to the state of the art.

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Reference is made to the following documents:

D1: KALEONG LO ET AL: "Layered space time coding with joint iterative detection, channel estimation and decoding" SPREAD SPECTRUM TECHNIQUES AND APPLICATIONS, 2002 IEEE SEVENTH INTERNATIONAL SYMPOSIUM ON SEPT. 2-5, 2002, PISCATAWAY, NJ, USA,IEEE, vol. 2, 2 September 2002 (2002-09-02), pages 308-312, XP010615481 ISBN: 0-7803-7627-7

D2: EP-A-1 211 819 (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD) 5 June 2002 (2002-06-05)

D3: WO 97/44916 A (NOKIA TELECOMMUNICATIONS OY; PIIRAINEN, OLLI) 27 November 1997 (1997-11-27)

D4: PAULRAJ A ET AL: "Introduction to Space-Time Wireless Communications" May 2003 (2003-05), CAMBRIDGE UNIVERSITY PRESS , CAMBRIDGE, U.K. , XP002333354 ISBN: 0 521 82615 2

D5: ZEMEN T ET AL: "Iterative detection and channel estimation for MC-CDMA" ICC 2003. 2003 IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS. ANCHORAGE, AK, MAY 11 - 15, 2003, IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS, NEW YORK, NY : IEEE, US, vol. VOL. 1 OF 5, 11 May 2003 (2003-05-11), pages 3462-3466, XP010643089 ISBN: 0-7803-7802-4

D6: RALEIGH G G ET AL: "MULTIVARIATE MODULATION AND CODING FOR WIRELESS COMMUNICATION" IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, IEEE INC. NEW YORK, US, vol. 17, no. 5, May 1999 (1999-05), pages 851-866, XP000830239 ISSN: 0733-8716

D7: JIE ZHU ET AL: "Channel estimation with power-controlled pilot symbols and decision-directed reference symbols [OFDM systems]" VEHICULAR TECHNOLOGY CONFERENCE, 2003. VTC 2003-FALL. 2003 IEEE 58TH ORLANDO, FL, USA 6-9 OCT. 2003, PISCATAWAY, NJ, USA,IEEE, US, 6 October 2003 (2003-10-06), pages 1268-1272Vol2, XP010700808 ISBN: 0-7803-7954-3

D8: COLERI S ET AL: "Channel Estimation Techniques Based on Pilot Arrangement in OFDM Systems" IEEE TRANSACTIONS ON BROAD6ASTING, vol. 48, no. 3, September 2002 (2002-09), pages 223-229, XP002344335

D9: MEYR H ET AL: "Digital Communication Receivers: Synchronization, Channel Estimation, and Signal Processing" 1998, WILEY-INTERSCIENCE , NEW YORK, U.S.A , XP002344337

Invention I.

The requirements of Article 6 PCT

2.1 Claim 1 claims a method of recovering first and second data streams transmitted simultaneously via a wireless channel. The scope of claim 1 thus extends to many different type of wireless communication systems, such as CDMA systems, OFDM systems, or multiantenna systems, in each of which a plurality of data streams are transmitted simultaneously via a transmission channel. All the embodiments disclosed in the description, however, are restricted to hierarchical transmission, wherein two data streams (the base stream and the enhancement stream) are combined prior to transmission by combining data symbols for the base stream and enhancement stream

by either adding or mapping the respective data symbols to obtain a combined symbol. Unlike in CDMA, OFDM, or multiantenna systems, the two data streams are not multiplexed in the frequency domain, the spatial domain or the code-domain. Furthermore, the modification of the claimed subject-matter to these other types of communication systems cannot be regarded as obvious to the skilled person. It thus appears that claim 1 is not supported over the whole of its breadth, as required by Article 6 PCT.

It is pointed out that the same objections is also applicable to the other independent claims 27 and 30.

2.2 According to claim 1, a first channel estimate is derived based on received symbols. The scope of claim 1 thus encompasses deriving a first channel estimate based on received pilot symbols or received data symbols. The embodiments disclosed in the description, however, only describe pilot-based channel estimation. It thus appears that claim 1 is not supported over the whole of its breadth, as required by Article 6 PCT.

It is pointed out that the same objections is also applicable to the other independent claims 27 and 30.

2.3 According to claim 1, a second channel estimate is derived based on the detected data stream. With such a definition, the subject-matter of claim 1 encompasses methods which are not disclosed or envisioned by the present application, for example, cancelling the effect of the detected first stream from the received symbols, and deriving the second channel estimate therefrom (i.e. iterative channel estimation). The disclosed embodiments, however, only envision a data-directed channel estimation, wherein either detected symbols, or decoded and re-encoded and remodulated symbols are used in lieu of known pilot symbols. It is thus concluded that claim 1 is not adequately supported over the whole of its breadth, as required by Article 6 PCT.

It is pointed out that the same objections is also applicable to the other independent claims 27 and 30.

2.4 According to claim 1, the second data stream is detected using the third channel

estimate. According to all the disclosed embodiments, however, the interference due to the first stream is estimated using the 3rd channel estimate, and this estimated interference is cancelled from the received combined data symbols, prior to detecting the second data stream. It thus appears that features which are essential to performing the invention are lacking from claim 1, thus rendering the scope of claim 1 unclear (Article 6 PCT).

It is pointed out that the same objections is also applicable to the other independent claims 27 and 30.

The requirements of Article 33 PCT

3.1 The document D1 discloses (the references in parentheses applying to this document) according to all features of claim 1,

A method of recovering first and second data streams transmitted simultaneously via a wireless channel in a wireless communication system (see page 308, right-hand column, up to and including Figure 1 which discloses nT data streams transmitted simultaneously over a wireless channel in a wireless communication system, and page 308, right-hand column, text following Figure 1 - page 309, left-hand column, up to Section III, which discloses recovering the nT transmitted data streams), comprising:

deriving a first channel estimate for the wireless channel based on received symbols (see page 311, left-hand column, up to the first two lines after equation (18));
performing detection for the first data stream using the first channel estimate (see Figure 3 and page 311, left-hand column, up to the first two lines after equation (18), at the first iteration, the first, pilot-based, channel estimate is used in the parallel interference cancellation detector which detects the nT data streams);
deriving a second channel estimate based on the detected first data stream (see page 311, left-hand column, equation (19), which shows how to calculate a second channel estimate at iteration k=2, based on the first channel estimate at iteration k=1);
deriving a third channel estimate based on the first and second channel estimates (see, for example, page 311, left-hand column, equation (19), which shows how to calculate a third channel estimate at iteration k=3, based on the second channel estimate at

iteration k=2 which in turn is based on the first channel estimate at iteration k=1, or, alternatively, page 311, left-hand column, equation (21), which shows how to calculate a third channel estimate at iteration k=2, based on the second estimate at iteration k=2 and the first estimate at iteration k=1); and
performing detection for the second data stream using the third channel estimate (see Figure 3 and page 311, left-hand column, equation (19), at the third iteration, the third channel estimate is used in the parallel interference cancellation detector which detects the nT data streams).

Claim 1 thus lacks novelty over the prior art document D1 in the sense of Article 33(2) PCT.

3.2 Independent claims 27 and 30 contain essentially the same technical features as claim 1, except that they are formulated as apparatus features. Therefore, document D1 discloses all the features of claims 27 and 30 as well, and these claims thus lack novelty over the prior art document D1 in the sense of Article 33(2) PCT.

3.3 The document D5 discloses (the references in parentheses applying to this document) according to the features of claim 3,

A method of recovering first and second data streams transmitted simultaneously via a wireless channel in a wireless communication system (see page 3462, left-hand column, Introduction, which discloses a method of recovering the data transmitted in a multicarrier CDMA system; in a multicarrier system, by definition, a plurality of data streams are transmitted simultaneously on the plurality of subcarriers; furthermore, see page 3465, right-hand column, Section VI, first four lines, which discloses a wireless channel), comprising:

deriving a first channel estimate for the wireless channel based on received symbols (see page 3464, right-hand column, last two lines up to page 3465, left-hand column, equation (7));
performing detection for the first data stream using the first channel estimate (see 3465, left-hand column, paragraph starting with "The channel impulse response in the time domain ...", which discloses that the channel estimate is used for data detection;

furthermore, see Figure 2, which shows that the first data stream is detected using the channel estimate);

deriving a second channel estimate based on the detected first data stream (see page 3465, left-hand column, one line above equation (7) up to the end of the left-hand column, which discloses estimating further channel estimates in further iterations);

deriving a third channel estimate based on the first and second channel estimates (see page 3465, left-hand column, one line above equation (7) up to the end of the left-hand column and Figure 8, which discloses estimating further channel estimates in further iterations; at a third iteration, the third channel estimate is based on the data estimate of the second iteration. The estimated data of the second iteration is based on the second channel estimate at the second iteration. The second channel estimate is, in turn, based on the estimated data of the first iteration. The estimated data of the first iteration is based on the first channel estimate at the first iteration. Therefore, the third channel estimate is based on the first and second channel estimates);

and

performing detection for the second data stream using the third channel estimate (see Figure 2, which shows how all the data streams are detected in each iteration. In a third iteration, the third channel estimate is thus used for detecting the second data stream);

further comprising estimating interference due to the first data stream using the third channel estimate, and wherein the detection for the second data stream is performed with the estimated interference from the first data stream cancelled (see Figure 2, which discloses that at each iteration, all data-streams are detected by a parallel interference cancellation process. Parallel interference cancellation is well known in the art and implies that the interfering data streams are estimated and cancelled when the desired data stream is detected. In the third iteration, the interference from a first data stream is thus estimated by the parallel interference canceller using the third channel estimate, and cancelled for the detection of a second data stream).

Claim 3 thus lacks novelty over the prior art document D5 in the sense of Article 33(2) PCT.

3.4 Furthermore, according to claim 4, the first and second data streams are combined prior to transmission via the wireless channel. Documet D5 discloses, in that respect, combining the N subcarriers, i.e. the N data streams, prior to transmission via an IFFT

operation (see Figure 1).

Claim 4 thus lacks novelty over the prior art document D5 in the sense of Article 33(2) PCT.

3.5 The additional features of the dependent claims 2, 3, 12, 15-19, 26, 28, 31 do not add anything which would result in new and inventive independent claims, because these features are either known from the above prior art D1,

- claim 2: see document D1, page 311, left-hand column, first paragraph
- claims 3, 28, 31: see document D1, page 311, left-hand column, equation (3): in iteration k=4 the interference due to the first data stream is estimated using the channel estimate from iteration k=3), and wherein the detection for the second data stream is performed with the estimated interference from the first data stream cancelled (see Figure 3 and page 311, left-hand column, equation (3): the channel estimate from transmit antenna I to receive antenna j is computed with the interference due to the other transmit antennas cancelled. Since transmit antenna I is associated with data stream I, the channel estimate from transmit antenna I to receive antenna j is computed with the interference due to the other data streams cancelled. The channel estimate from transmit antenna 2 to any receive antenna is thus computed with the interference from the first data stream cancelled. Consequently, all the data streams, and thus the second data stream, are detected with the estimated interference from the first data stream cancelled from this channel estimate
- claims 15-19: see document D1, page 311, left-hand column, paragraph starting after equation (20) - page 311, right-hand column, first paragraph, and in particular equation (21) which discloses scaling, or filtering, of channel estimates
- claim 26: see document D1, Figure 1

or common design measures, for example,

- claim 12, document D1 discloses detection for the first data stream performed on received data symbols. Providing detected symbols is considered as common general knowledge of the skilled person

3.6 There is no doubt with respect to the industrial applicability of claims 1-4, 12, 15-19, 26-28, 30, 31 (Article 33(4) PCT).

Invention II.

The requirements of Article 33 PCT

4.1 The document D5 discloses (the references in parentheses applying to this document) according to the features of claim 5,

A method of recovering first and second data streams transmitted simultaneously via a wireless channel in a wireless communication system (see page 3462, left-hand column, Introduction, which discloses a method of recovering the data transmitted in a multicarrier CDMA system; in a multicarrier system, by definition, a plurality of data streams are transmitted simultaneously on the plurality of subcarriers; furthermore, see page 3465, right-hand column, Section VI, first four lines, which discloses a wireless channel), comprising:

deriving a first channel estimate for the wireless channel based on received symbols (see page 3464, right-hand column, last two lines up to page 3465, left-hand column, equation (7));
performing detection for the first data stream using the first channel estimate (see 3465, left-hand column, paragraph starting with "The channel impulse response in the time domain ...", which discloses that the channel estimate is used for data detection; furthermore, see Figure 2, which shows that the first data stream is detected using the channel estimate);
deriving a second channel estimate based on the detected first data stream (see page 3465, left-hand column, one line above equation (7) up to the end of the left-hand column, which discloses estimating further channel estimates in further iterations);
deriving a third channel estimate based on the first and second channel estimates (see page 3465, left-hand column, one line above equation (7) up to the end of the left-hand column and Figure 8, which discloses estimating further channel estimates in further iterations; at a third iteration, the third channel estimate is based on the data estimate of the second iteration. The estimated data of the second iteration is based on the

second channel estimate at the second iteration. The second channel estimate is, in turn, based on the estimated data of the first iteration. The estimated data of the first iteration is based on the first channel estimate at the first iteration. Therefore, the third channel estimate is based on the first and second channel estimates);
and
performing detection for the second data stream using the third channel estimate (see Figure 2, which shows how all the data streams are detected in each iteration. In a third iteration, the third channel estimate is thus used for detecting the second data stream);
wherein deriving a first channel estimate includes
obtaining a frequency response estimate for the wireless channel based on the received pilot symbols (see page 3464, right-hand column, last two lines up to page 3465, left-hand column, second line after equation (6)),
deriving a time-domain impulse response estimate for the wireless channel based on the frequency response estimate (see page 3465, left-hand column, paragraph starting with "The channel impulse response in the time domain ..."), and
deriving the first channel estimate based on the time-domain impulse response (see equation above equation (7))

Claim 5 thus lacks novelty over the prior art document D5 in the sense of Article 33(2) PCT.

4.2 Claim 7 merely differs from claim 5 in that the second channel estimate is derived based on the time-domain impulse response, whereas in claim 5 the first channel estimate is derived based on the time-domain impulse response.

As demonstrated in Point 4.1, the second channel estimate is based on the estimated data of the first iteration, and the estimated data of the first iteration is based on the first channel estimate at the first iteration. Therefore, the second channel estimate is based on the first channel estimate. Since the first channel estimate is based on the time-domain impulse response, the second channel estimate is also based on the time-domain impulse response.

Claim 7 thus lacks novelty over the prior art document D5 in the sense of Article 33(2) PCT.

4.3 According to the additional features of dependent claim 6, the first channel estimate is derived by performing an FFT on the time-domain impulse response, which, in turn in derived by performing an IFFT on the frequency response estimate. The net effect of these features is thus that the first channel estimate is equal to the frequency response estimate. It thus appears that the additional features of dependent claim 6 do not have any technical effect, and thus cannot contribute towards an inventive step (Article 33(3) PCT).

4.4 There is no doubt with respect to the industrial applicability of claims 5-7 (Article 33(4) PCT).

Invention III.

The requirements of Article 6 PCT

5.1 According to claim 8, the first and second channel estimates are time-domain impulse response estimates. According to antecedent claim 1, this time-domain impulse response estimate is used to perform detection for the first data stream. Furthermore, according to claim 8, the third channel estimate is a frequency response estimate. According to antecedent claim 1, this frequency response estimate is used to perform detection for the second data stream.

The description, however, does not disclose a method of recovering the first data stream using a time-domain impulse response estimate, and the second data stream using a frequency response estimate: According to the disclosed embodiments (and see in particular paragraph 50), a frequency response estimate of the channel at the pilot positions is derived and transformed into the time-domain. This estimate is zero padded and transformed back into the frequency domain and used as the first channel estimate to perform detection of the first stream. The first channel estimate is thus a frequency response estimate.

Claim 8 is thus not supported by the description as required by Article 6 PCT. Furthermore, it is not clear at all to the skilled person what type of transmitted signal may

be recovered with the method according to claim 8, wherein the first data stream is detected in the time domain, and the second data stream, which is simultaneously transmitted over the wireless channel, is detected in the frequency domain (Article 6 PCT).

The requirements of Article 33 PCT

5.2 Prior art document D1 assumes MIMO wireless transmission over a flat fading channel (see page 308, lines 1-3 of Section 2.). It is well known in the art, that realistic wireless channels are not of a flat, but a frequency selective nature, and that OFDM is the method of choice to covert a frequency-selective MIMO channel into a frequency-flat MIMO channel. The skilled person would thus consider employing OFDM in order to adapt the method disclosed in document D1 to realistic, frequency selective MIMO channels. For implementation details, such as channel estimation, the skilled person would turn to documents such as D6, which disclose how to employ OFDM in the context of a frequency-selective MIMO channel. In document D6, it is disclosed, in line with what is actually supported by the description (see also Point 5.1) , that a frequency response estimate of the channel at the pilot positions is derived and transformed into the time-domain. This estimate is zero padded and transformed back into the frequency domain and used as a channel estimate to perform detection (see page 860, right-hand column, step 1) up to page 861, left-hand column, step 4) of the channel estimation algorithm). The subject-matter of claim 8 is thus obvious to the skilled person, and consequently does not involve an inventive step in the sense of Article 33(3) PCT.

5.3 There is no doubt with respect to the industrial applicability of claim 8 (Article 33(4) PCT).

Invention IV.

The requirements of Article 33 PCT

6.1 The document D7 discloses (the references in parentheses applying to this document) according to the features of claim 9,

A method of recovering first and second data streams transmitted simultaneously via a

wireless channel in a wireless communication system (see page 1268, left-hand column, lines 1-15 of the Introduction, which disclose that the document discloses a wireless OFDM communication system communicating over a wireless channel; furthermore, see page 1269, left-hand column, Section "II. System Model", up to the first line after equation (2) which discloses that N subcarriers, i.e. data streams, are transmitted simultaneously over the channel; finally see Figure 1, which discloses a method of recovering the N subcarriers), comprising:

deriving a first channel estimate for the wireless channel based on received symbols (see page 1269, right-hand column, Section III. A., step a.)
performing detection for the first data stream using the first channel estimate (see page 1269, right-hand column, Section III. A. step b. up to page 1270, left-hand column, step c.);
deriving a second channel estimate based on the detected first data stream (see page 1270, left-hand column, steps d. and e., which discloses the selection of re-modulated data symbols as virtual pilot symbols, and the refinement of the channel estimation using a combination of real and virtual pilots. With respect to the refinement of the channel estimate, see page 1269, right-hand column, lines 11-19, which discloses a two-step procedure: LS estimation followed by interpolation. The LS estimation of the combination of real and virtual pilots thus results in a second channel estimate according to the features of claim 9)
deriving a third channel estimate based on the first and second channel estimates (see page 1270, left-hand column, steps d. and e., which discloses the selection of re-modulated data symbols as virtual pilot symbols, and the refinement of the channel estimation using a combination of real and virtual pilots. With respect to the refinement of the channel estimate, see page 1269, right-hand column, lines 11-19, which discloses a two-step procedure: LS estimation followed by interpolation. The result of the interpolation is the third channel estimate according to the features of claim 9), and
performing detection for the second data stream using the third channel estimate (see Figure 1),
wherein the first channel estimate comprises channel gain estimates for a first group of subbands (see page 1269, right-hand column, Section III. A., step a. which discloses using pilots, and see also page 1269, left-hand column, Section "II. System Model" up to the fourth line after equation (1), which discloses that pilots are transmitted on a group

of subcarriers)
and the second channel estimate comprises channel gain estimates for a second group of subbands (see page 1270, left-hand column, steps d. and e., which disclose the selection of re-modulated symbols on certain subcarriers, and using these re-modulated symbols for channel estimation), and wherein the third channel estimate is derived based on a concatenation of the channel gain estimates for the first and second groups of subbands (see page 1270, left-hand column, steps d. and e., which disclose the selection of re-modulated symbols on certain subcarriers, and using these re-modulated symbols in combination with the pilot symbols for channel estimation; as explained further above, the output of the interpolator is the third channel estimate in the sense of claim 9).

Claim 9 is therefore not novel in the sense of Article 33(2) PCT.

6.2 The features of claim 11 are disclosed in document D7, page 1269, left-hand column, Section "II. System Model" up to the fourth line after equation (1), which discloses that pilots are transmitted on a group of subcarriers and data symbols on another group of subcarriers.

Claim 11 is therefore not novel in the sense of Article 33(2) PCT.

6.3 There is no doubt with respect to the industrial applicability of claims 9 and 11 (Article 33(4) PCT).

Invention V.

<u>The requirements of Article 33 PCT</u>

7.1 The document D5 discloses (the references in parentheses applying to this document) according to the features of claim 13,

A method of recovering first and second data streams transmitted simultaneously via a wireless channel in a wireless communication system (see page 3462, left-hand column, Introduction, which discloses a method of recovering the data transmitted in a

multicarrier CDMA system; in a multicarrier system, by definition, a plurality of data streams are transmitted simultaneously on the plurality of subcarriers; furthermore, see page 3465, right-hand column, Section VI, first four lines, which discloses a wireless channel), comprising:

deriving a first channel estimate for the wireless channel based on received symbols (see page 3464, right-hand column, last two lines up to page 3465, left-hand column, equation (7));
performing detection for the first data stream using the first channel estimate (see 3465, left-hand column, paragraph starting with "The channel impulse response in the time domain ...", which discloses that the channel estimate is used for data detection; furthermore, see Figure 2, which shows that the first data stream is detected using the channel estimate);
deriving a second channel estimate based on the detected first data stream (see page 3465, left-hand column, one line above equation (7) up to the end of the left-hand column, which discloses estimating further channel estimates in further iterations);
deriving a third channel estimate based on the first and second channel estimates (see page 3465, left-hand column, one line above equation (7) up to the end of the left-hand column and Figure 8, which discloses estimating further channel estimates in further iterations; at a third iteration, the third channel estimate is based on the data estimate of the second iteration. The estimated data of the second iteration is based on the second channel estimate at the second iteration. The second channel estimate is, in turn, based on the estimated data of the first iteration. The estimated data of the first iteration is based on the first channel estimate at the first iteration. Therefore, the third channel estimate is based on the first and second channel estimates);
and
performing detection for the second data stream using the third channel estimate (see Figure 2, which shows how all the data streams are detected in each iteration. In a third iteration, the third channel estimate is thus used for detecting the second data stream);
and further comprising:
decoding the detected symbols for the first data stream to obtain decoded data for the first data stream (see Figure 2, where all the streams are decoded); and
re-encoding the decoded data to obtain remodulated symbols for the first data stream (see Figure 2, which shows that the output of the channel decoder is re-encoded by an

interleaver followed by a mapper), and wherein the second channel estimate is derived based on the remodulated symbols and the received data symbols (see page 3465, left-hand column, one line above equation (7) up to the end of the left-hand column, which discloses estimating further channel estimates in further iterations)

Furthermore, it is pointed out that, according to claim 34, the decoded data is re-encoded. The term re-encode is not strictly limited to re-encoding with a channel encoder, and the operations of interleaving and mapping, as shown in Figure 2 of document D5, are consequently interpreted as a re-encoding operation

Claim 13 thus lacks novelty over the prior art document D5 in the sense of Article 33(2) PCT.

7.2 For the additional features of claim 14, see document D5, page 3465, left-hand column, one line above equation (7) up to the second line after equation (7).

Claim 14 thus lacks novelty over the prior art document D5 in the sense of Article 33(2) PCT.

7.3 Independent claims 29 and 32 contain essentially the same technical features as claim 9, except that they are formulated as apparatus features. Therefore, document D5 discloses all the features of claims 29 and 32 as well, and these claims thus lack novelty over the prior art document D5 in the sense of Article 33(2) PCT.

7.4 The document D5 discloses (the references in parentheses applying to this document) according to the features of claim 33,

A method of recovering first and second data streams transmitted simultaneously via a wireless channel in a wireless communication system (see page 3462, left-hand column, Introduction, which discloses a method of recovering the data transmitted in a multicarrier CDMA system; in a multicarrier system, by definition, a plurality of data streams are transmitted simultaneously on the plurality of subcarriers; furthermore, see page 3465, right-hand column, Section VI, first four lines, which discloses a wireless channel), comprising:

deriving a first channel estimate for the wireless channel based on received pilot symbols (see page 3464, right-hand column, last two lines up to page 3465, left-hand column, equation (7));
performing detection for the first data stream using the first channel estimate to obtain detected symbols for the first data stream (see 3465, left hand column, paragraph starting with "The channel impulse response in the time domain ...", which discloses that the channel estimate is used for data detection; furthermore, see Figure 2, which shows that the first data stream is detected using the channel estimate);
decoding the detected symbols for the first data stream to obtain decoded data for the first data stream (see Figure 2, which shows that a chain of demapper, deinterleaver and channel decoder delivers decoded data for all the data streams);
re-encoding the decoded data for the first data stream to obtain remodulated symbols for the first data stream (see Figure 2, which shows that the output of the channel decoder is re-encoded by an interleaver followed by a mapper)
deriving a second channel estimate based on the remodulated symbols (see page 3465, left-hand column, one line above equation (7) up to the end of the left-hand column, which discloses estimating further channel estimates in further iterations);
deriving a third channel estimate based on the first and second channel estimates (see page 3465, left-hand column, one line above equation (7) up to the end of the left-hand column and Figure 8, which discloses estimating further channel estimates in further iterations; at a third iteration, the third channel estimate is based on the data estimate of the second iteration. The estimated data of the second iteration is based on the second channel estimate at the second iteration. The second channel estimate is, in turn, based on the estimated data of the first iteration. The estimated data of the first iteration is based on the first channel estimate at the first iteration. Therefore, the third channel estimate is based on the first and second channel estimates);
estimating interference due to the first data stream using the third channel estimate (see Figure 2, which discloses estimating interference due to all data streams by means of a parallel interference canceller)
performing detection for the second data stream, with the estimated interference from the first data stream cancelled, and using the third channel estimate, to obtain detected symbols for the second data stream (see Figure 2, which shows how all the data streams are detected in each iteration. In a third iteration, the third channel estimate is thus used for detecting the second data stream; the interference from the first data stream is

cancelled by the parallel interference canceller); and
decoding the detected symbols for the second data stream to obtain decoded data for the second data stream (see Figure 2, which discloses how all the data streams are decoded by a chain of demapper, deinterleaver, and channel decoder).

Claim 33 only differs from prior art document D5 in that it explicitly states that the first data stream is a base stream and the second data stream is an enhancement stream. In document D5, it is not explicitly stated what is transmitted in each subchannel. However, it is obvious to a skilled person that in a multicarrier CDMA system, a base stream and an enhancement stream may be transmitted on different subchannels. Claim 33 is thus considered to lack an inventive step in the sense of Article 33(3) PCT.

7.5 Document D5 discloses the additional features of claim 34, i.e.

wherein deriving a first channel estimate includes
obtaining a frequency response estimate for the wireless channel based on the received pilot symbols (see page 3464, right-hand column, last two lines up to page 3465, left-hand column, second line after equation (6)),
deriving a time-domain impulse response estimate for the wireless channel based on the frequency response estimate (see page 3465, left-hand column, paragraph starting with "The channel impulse response in the time domain ..."), and
deriving the first channel estimate based on the time-domain impulse response (see equation above equation (7))

Claim 34 is thus considered to lack an inventive step in the sense of Article 33(3) PCT.

7.6 There is no doubt with respect to the industrial applicability of claims 13-14, 29, 32-34 (Article 33(4) PCT).

Invention VI.

<u>The requirements of Article 33 PCT</u>

8.1 The document D7 discloses (the references in parentheses applying to this document)

according to the features of claim 20,

A method of recovering first and second data streams transmitted simultaneously via a wireless channel in a wireless communication system (see page 1268, left-hand column, lines 1-15 of the Introduction, which disclose that the document discloses a wireless OFDM communication system communicating over a wireless channel; furthermore, see page 1269, left-hand column, Section "II. System Model", up to the first line after equation (2) which discloses that N subcarriers, i.e. data streams, are transmitted simultaneously over the channel; finally see Figure 1, which discloses a method of recovering the N subcarriers), comprising:

deriving a first channel estimate for the wireless channel based on received symbols (see page 1269, right-hand column, Section III. A., step a.)
performing detection for the first data stream using the first channel estimate (see page 1269, right-hand column, Section III. A. step b. up to page 1270, left-hand column, step c.);
deriving a second channel estimate based on the detected first data stream (see page 1270, left-hand column, steps d. and e., which discloses the selection of re-modulated data symbols as virtual pilot symbols, and the refinement of the channel estimation using a combination of real and virtual pilots. With respect to the refinement of the channel estimate, see page 1269, right-hand column, lines 11-19, which discloses a two-step procedure: LS estimation followed by interpolation. The LS estimation of the combination of real and virtual pilots thus results in a second channel estimate according to the features of claim 9)
deriving a third channel estimate based on the first and second channel estimates (see page 1270, left-hand column, steps d. and e., which discloses the selection of re-modulated data symbols as virtual pilot symbols, and the refinement of the channel estimation using a combination of real and virtual pilots. With respect to the refinement of the channel estimate, see page 1269, right-hand column, lines 11-19, which discloses a two-step procedure: LS estimation followed by interpolation. The result of the interpolation is the third channel estimate according to the features of claim 9), and
performing detection for the second data stream using the third channel estimate (see Figure 1), further comprising:
filtering the first, second, or third channel estimate in the frequency domain (see page

1269, right-hand column, lines 16-19, which discloses interpolation, i.e. filtering, in the frequency domain)

Claim 20 is therefore not novel in the sense of Article 33(2) PCT.

8.2 According to claim 21, filtering is performed with an IIR filter. Document D7 discloses, in that respect, low-pass interpolation (see page 1269, right-hand column, lines 16-19). It is obvious to the skilled person that such a low-pass filter may be an IIR filter. Claim 21 is therefore not involving an inventive step in the sense of Article 33(3) PCT.

According to claim 22, filtering is performed with an FIR filter. Document D7 discloses, in that respect, low-pass interpolation (see page 1269, right-hand column, lines 16-19). It is obvious to the skilled person that such a low-pass filter may be an FIR filter. Claim 21 is therefore not involving an inventive step in the sense of Article 33(3) PCT.

8.3 There is no doubt with respect to the industrial applicability of claims 20-22 (Article 33(4) PCT).

Invention VII.

<u>The requirements of Article 33 PCT</u>

9.1 The document D7 discloses (the references in parentheses applying to this document) according to the features of claim 23,

A method of recovering first and second data streams transmitted simultaneously via a wireless channel in a wireless communication system (see page 1268, left-hand column, lines 1-15 of the Introduction, which disclose that the document discloses a wireless OFDM communication system communicating over a wireless channel; furthermore, see page 1269, left-hand column, Section "II. System Model", up to the first line after equation (2) which discloses that N subcarriers, i.e. data streams, are transmitted simultaneously over the channel; finally see Figure 1, which discloses a method of recovering the N subcarriers), comprising:

deriving a first channel estimate for the wireless channel based on received symbols (see page 1269, right-hand column, Section III. A., step a.)

performing detection for the first data stream using the first channel estimate (see page 1269, right-hand column, Section III. A. step b. up to page 1270, left-hand column, step c.);

deriving a second channel estimate based on the detected first data stream (see page 1270, left-hand column, steps d. and e., which discloses the selection of re-modulated data symbols as virtual pilot symbols, and the refinement of the channel estimation using a combination of real and virtual pilots. With respect to the refinement of the channel estimate, see page 1269, right-hand column, lines 11-19, which discloses a two-step procedure: LS estimation followed by interpolation. The LS estimation of the combination of real and virtual pilots thus results in a second channel estimate according to the features of claim 9)

deriving a third channel estimate based on the first and second channel estimates (see page 1270, left-hand column, steps d. and e., which discloses the selection of re-modulated data symbols as virtual pilot symbols, and the refinement of the channel estimation using a combination of real and virtual pilots. With respect to the refinement of the channel estimate, see page 1269, right-hand column, lines 11-19, which discloses a two-step procedure: LS estimation followed by interpolation. The result of the interpolation is the third channel estimate according to the features of claim 9), and

performing detection for the second data stream using the third channel estimate (see Figure 1), wherein

the wireless communication system utilizes orthogonal frequency division multiplexing (see page 1268, left-hand column, lines 1-15 of the Introduction, which disclose that the document discloses a wireless OFDM communication system communicating over a wireless channel)

Claim 23 is therefore not novel in the sense of Article 33(2) PCT.

9.2 The features of claim 24 are disclosed in document D7, page 1269, left-hand column, Section "II. System Model" up to the fourth line after equation (1), and page 1269, right-hand column, equations (5) and (6), which disclose obtaining received pilots $R_i(mL)$ in each symbol period I that are transmitted on a set of subcarriers of an OFDM system.

Claim 24 is therefore not novel in the sense of Article 33(2) PCT.

9.3 The document D8 discloses (the references in parentheses applying to this document) according to the features of claim 25,

A method of recovering first and second data streams transmitted simultaneously via a wireless channel in a wireless communication system (see page 223, left-hand column, Introduction, which discloses OFDM transmission over wireless channels; furthermore, see page 224, left-hand column, lines 1-5 and equation (1) which discloses transmitting N subcarriers, i.e. N data streams, simultaneously; finally, see page 225, left-hand column, equation (14), which discloses detecting the N subcarriers), comprising:

deriving a first channel estimate for the wireless channel based on received symbols (see either equation (11) on the right-hand column of page 224, or equation (12) on the left-hand column of page 225)
performing detection for the first data stream using the first channel estimate (see page 225, left-hand column, equation (14), which discloses detecting the N subcarriers);
deriving a second channel estimate based on the detected first data stream (see page 225, left-hand column, equation (15)),
performing detection for the second data stream using the second channel estimate (see Figure 1, which shows that channel estimates are used in the detection of all N subcarriers; it is implicitly clear that the second, updated, channel estimate is used in the detection process), wherein
the wireless communication system utilizes orthogonal frequency division multiplexing (see Figure 1), and wherein
the received pilot symbols are obtained for OFDM symbol periods used for pilot transmission, wherein the first channel estimate is derived for each OFDM symbol period used for pilot transmission, and wherein the second channel estimate is derived for each OFDM symbol period used for data transmission (see page 224, right-hand column, first three lines of Section III, and page 225, left-hand column, lines 10-22)

Claim 25 differs from the disclosure of document D8 in that a third channel estimate is derived based on the first and second channel estimates, and that the third channel estimate is used in-lieu of the second channel estimate in the detection of the second

data stream.

Claim 25 is thus novel over prior art document D8 (Article 33(2) PCT).

Since the second channel estimate disclosed in document D8 is based via equation (14) on the first channel estimate, the objective technical problem to be solved by claim 25 may thus be regarded as how to improve, or refine, the second channel estimate.

The solution offered by claim 25 is not regarded to involve an inventive step in the sense of Article 33(3) PCT, for the following reason:

Document D8 clearly states that channel estimation may be performed by either LS or MMSE estimation. It is common general knowledge of the skilled person (i.e. textbook knowledge), that MMSE channel estimation performs better than LS channel estimation (since it includes a-priori knowledge about channel statistics), and that MMSE estimation may be written in terms of Wiener-filtering LS estimates (see, for example, document D9, page 649, Section starting with "Case 1:" up to page 650, Section starting with "Case 2:). If prompted to improve the second channel estimate according to equation (15) on page 225, left-hand column, of document D8, the skilled person would thus consider using MMSE estimation instead of the LS estimation used in equation (15). Since the skilled person knows that the MMSE estimate may be obtained simply by filtering the LS estimate of equation (15), this would be the obvious choice. The MMSE estimate is thus the third channel estimate in the sense of claim 25.

9.4 There is no doubt with respect to the industrial applicability of claims 23-25 (Article 33(4) PCT).